DOCUMENT RESUME

ED 309 958 SE 050 795

AUTHOR Schaalma, Deborah
TITLE Gender Differences in Mathematics Achievement: Do They Exist? If So, What Are Their Causes?
PUB DATE 6 Jul 89
NOTE 45p.; In partial fulfillment of the requirements for S591-Exit Project.
PUB TYPE Information Analyses (070) -- Reference Materials - Bibliographies (131)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Affective Behavior; Educational Improvement; Females; Literature Reviews; *Mathematics Achievement; Mathematics Education; *Parent Attitudes; *Sex Differences; *Student Attitudes; *Teacher Attitudes

ABSTRACT

The purpose of the study was to identify possible causes of gender differences in mathematics achievement. Educators need to be aware that gender differences may exist and encourage all students in the study of mathematics. Annotations of 38 articles and a glossary are included. It was concluded that affective factors are responsible for differences when they do occur. These may include student, parent, and teacher attitudes, and experiences outside of the classroom. Eleven recommendations are provided including: (1) teachers should provide information about math-related careers and the amount of mathematics required to enter those careers; (2) teachers should provide activities which allow students to practice spatial skills; (3) research must continue to investigate further what can be done to close the gap in mathematics achievement; (4) the SAT should be examined to determine if it is a fair predictor of achievement for both males and females; and (5) parents should be made aware of the importance of mathematics for all students, not just males; and of how their own attitudes affect the attitudes of their children. (CW)

**********
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
**********

ED309958

# Gender Differences in Mathematics Achievement: Do They Exist? If So, What Are Their Causes?

A Study By

Deborah Schaalma

under the direction of

Charles R. DuVall, Ph.D.

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Deborah Schaalma

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

In partial fulfillment of the requirements for

S591--Exit Project

July 6, 1989

SE 050 795



BEST COPY AVAILABLE

Table of Contents

Introduction . . . . . 1

Statement of the Problem . . . . . 2

Purpose of the Study . . . . . 2

Organization of the Study . . . . . 2

Limitations of the Study . . . . . 3

Glossary . . . . . 4

Annotations . . . . . 7

Student Attitudes . . . . . 7

Teacher/Student Interactions and Classroom Activities . . . . . 12

Parent Attitudes and Influences . . . . . 15

Achievement Differences in Elementary and Junior High Schools . . . . . 18

Achievement Differences in High Schools . . . . . 22

Summary . . . . . 28

Conclusions . . . . . 34

Recommendations . . . . . 36

Bibliography . . . . . 38

## Introduction

In spite of the fact that equality of the sexes in schools and in the workplace has been mandated by law for quite some time, there still appear to be some inequities in participation and achievement in secondary school mathematics (Burton, 1984: 199). Students who elect to discontinue their mathematics studies essentially eliminate themselves from the majority of better paid occupations. Since women in the United States make up 43% of the workforce, it is essential that they help advance its technological needs (Rallis and Ahern, 1985: 3). Lucy Sells has described mathematics as a "critical filter" that limits the range of career choices available to those who take only the minimum number of courses in high school (Strauss, 1988: 533).

Females start out achieving at levels equal to males during the elementary school grades, but gender differences favoring males often begin during the middle school years (Marshall and Smith, 1987: 382-83). As educators, we must help encourage high school students, especially females, to continue to take as many mathematics courses as possible. To do this, we must understand why inequities in mathematics achievement occur in order to change the pattern of inequity.

## Statement of the Problem

Gender differences in mathematics achievement, if they do indeed exist, are caused by the attitudes and actions of parents, teachers, and the students themselves, as well as differential course-taking in high school.

## Purpose of the Study

The purpose of the study was to identify possible causes of gender differences in mathematics achievement. Educators need to be aware that gender differences may exist and encourage all students in the study of mathematics.

## Organization of the Study

the first part of the study will deal with student attitudes about mathematics and how they affect achievement. The second section will examine the influences teachers have on student participation in mathematics. Thirdly, the study will look at the influence of parents' attitudes on their children's mathematics achievement. The fourth section will investigate the differences in math achievement at the elementary and junior high levels. Finally, the study will survey differences between males and females in mathematics achievement at the high school level. Within each section, the annotations are arranged in alphabetical order.

## Limitations of the Study

There was a great deal of literature on gender differences in mathematics achievement even though several authors reviewed their studies for more than one journal. In view of some of the changing trends on this issue, this study focussed on the research articles published in 1984 or later, with five major exceptions. Five additional studies, published between 1977 and 1983, were included because they inspired so much of the later research (Benbow and Stanley, 1980, 1983; Fennema and Sherman, 1977; Senk and Usiskin, 1983; and Sherman and Fennema, 1977).

## Glossary

ability - the actual power present in an organism to successfully carry to completion any given act or to make adjustments successfully, the response being subject to voluntary control and dependent on the motivation of the subject to do his/her best performance. (Good, 1973)

ability grouping - grouping of pupils within classes or schools on the basis of some measured mental ability. (Good, 1973)

achievement - accomplishment or proficiency of performance in a given skill or body of knowledge. (Good, 1973)

achievement test - a standardized test designed to measure and compare levels of knowledge and understanding in a given subject already learned. (Hawes and Hawes, 1982)

affective domain - the area pertaining to feelings and emotions. (Good, 1973)

American College Testing Program (ACT) - a nonprofit educational organization that offers the widely used battery of "ACT" tests for college admissions. (Hawes and Hawes, 1982)

aptitude - ability measured by the amount of time required by the learner to acquire mastery of a task. (Good, 1973)

attitude - the predisposition or tendency to react specifically towards an object, situation, or value; usually accompanied by feelings and emotions. (Good, 1973)

cognitive domain - that mental functioning involved in perceiving, knowing, and understanding. (Good, 1973)

competitive activities - activities in which a rivalry between individuals takes place for supremacy in working for goals such as grades, prizes, or admissions. (Hawes and Hawes, 1982)

cooperative activities - activities in which two or more students are working together to achieve the same goal. (Peterson and Fennema, 1985)

deductive reasoning - drawing logical inferences from general principles for application to particular instances. (Hawes and Hawes, 1982)

Differential Aptitude Tests - a set of standardized tests widely used for career and educational counseling; among areas in which its constituent tests assess aptitudes are verbal reasoning, numerical ability, mechanical reasoning, clerical speed and accuracy, spelling, and perception of spatial relations. (Hawes and Hawes, 1982)

differential item performance - performance observed if, given examinees of equal abilities in the characteristic being measured by a set of items, the probability of answering an item correctly is related to group membership. (Doolittle and Cleary, 1987)

equity - equal access to information, as well as the participation in and infusion of gender-free activities. (Hearne, 1986)

Fennema-Sherman Mathematics Attitudes Scales - eight scales to determine student attitudes about mathematics; scales include Confidence in Learning Mathematics; (perceived attitude of) Mother; Father; Teacher (toward one as a learner of mathematics); Attitude toward Success in Mathematics, Effectance Motivation in Mathematics, Usefulness of Mathematics, and Mathematics as a Male Domain. (Sherman and Fennema, 1977)

grade-equivalent score - a converted score expressed in terms of a scale in which the grade is a unit of measurement and indicating the grade level of the group for which the score is typical or average (for example, 6.4 is the fourth month of sixth grade). (Good, 1973)

high-level mathematics - work at the comprehension, application or analysis levels. (Hart, 1989)

low-level mathematics - work mainly concerning computation. (Hart, 1989)

math as a male domain - the extent to which mathematics is perceived to be a subject more appropriate for males. (Pederson and others, 1986)

mathematical reasoning - reasoning which is either completely deductive or uses inductive or analogous reasoning to form hypotheses which are then subjected to deductive reasoning for confirmation or rejection. (Good, 1973)

proof - in logic, demonstration by established principles that a conclusion follows inescapably from given premises. (Hawes and Hawes, 1982)

schema - a cognitive representation of a particular stimulus domain which contains knowledge and which functions in the guiding, selecting, and processing of the vast array of information in the environment. (Krauser and Ballif, 1988)

Scholastic Aptitude Test (SAT) - a standardized test required for college admission, sponsored by The College Board and administered by the Educational Testing Service; yields a verbal score and a mathematical score, each reported on the SAT score scale ranging from a low of 200 to a high of 800. (Hawes and Hawes, 1982)

spatial visualization - the ability to mentally manipulate rotate, twist, or invert a pictorally presented stimulus object. (Fennema and Tartre, 1985)

stereotyping - a rigid impression of some category of individuals that is held by a person for all who are to be believed to be of that group regardless of experience with real people who do not fit that image. (Hawes and Hawes, 1982)

teacher wait-time - the length of time a teacher waits for a student to begin responding to a teacher-posed question. (Gore and Roumagoux, 1983)

verbal skills - language skills necessary to respond adequately in a situation requiring the communication of thought. (Good, 1973)

## Annotations

### Student Attitudes

Besag, Frank, and Maureen Wahl. "Gender, Race, Ethnicity and Math Avoidance." paper presented at the Anual Meeting of the American Educational Research Association, 1987.

This study investigated the variables that may have contributed to differential participation by sex of students in high school mathematics. Approximately 7,500 eleventh graders in a large midwestern school district were studied, with 100 of these students selected for an interview regarding their attitudes about mathematics.

The authors reported that males and females in this group took the same number and level of mathematics classes, but there was significant gender distinction in selecting math-related careers. Females were more likely to want marriage and a family instead of a career.

Burton, Grace M. "Revealing Images." School Science and Mathematics 84 (1984): 199-207.

This study was designed to determine student perceptions of the ideal mathematics student using the Mathematics Q-Sort. Two hundred five tenth grade geometry students were questioned. One disturbing discovery was that females rated "expecting to use mathematics in the future," on the average, only ninth out of 24 items.

Burton also gave a number of suggestions for teachers. To help encourage females and other minorities to continue in mathematics, they must be aware of its importance in career choices. She recommended that teachers provide students with information about math-related careers and the amount of mathematics needed to enter these fields through films and guest speakers.

Burton, Grace M., Ken Peterson, and Dale Baker. "Sex Differences in Geometry Students' Perceptions of Ideal and Actual Behavior." Journal for Research in Mathematics Education 18 (1985): 55-60.

The purpose of this study was to determine any differences between males and females in geometry students' perceptions of the attitudes and behaviors of the "ideal mathematics student," and their own attitudes and behaviors. Ninth and 10th grade students from Utah and North Carolina, who showed no significant differences in the letter grades received in geometry the previous semester, were the subjects of the study. They rated a list of 24 items about behavior and attitudes of mathematics students, first to describe the ideal student and then again to describe themselves.

The results showed that five items had significant differences between the sexes. Females thought the ideal student was concerned about grades, likely to volunteer to take part in class discussions, and able to make realistic estimation of their ability to do a mathematics problem or proof. Males described the ideal student as tense when about to do a difficult math problem and as expecting to take additional math classes.

In describing their own attitudes and behaviors, males and females differed on 13 of the items. Females focussed on items that showed a response to the expectations of others, like following directions, completing homework, and passing in papers that are neat and clean. Males, on the other hand, expected to use math in the future and had confidence that they could solve difficult math problems. The authors noted that teachers need to take into account student perceptions of themselves in the classroom in order to provide equity in the classroom.

Ethington, Corinna A., and Lee M. Wolfle. "A Structural Model of Mathematics Achievement for Men and Women." American Educational Research Journal 23 (1986): 65-75.

This study was a follow-up of High School and Beyond, a longitudinal study of 16,555 high school sophomores and seniors throughout the nation. For this study a comparison was made of sophomores from High School and Beyond with results obtained from these same students when they were seniors. This comparison involved the students' mathematics achievement along with their attitudes about math, and the math courses they had taken.

Those females who showed higher verbal ability had poorer attitudes about mathematics than their male counterparts, and attitudes had a stronger positive influence on mathematics achievement for men. The study also showed that higher mathematical ability and positive attitudes toward mathematics produced larger increases in mathematics achievement for males than females.

Krauser, Barbara Z., and Bonnie L. Ballif. "Casual Attributions of Adolescent Females in a Masculine Domain." 1988. ED 291 573

Krauser and Ballif examined how gender role and motivational variables contributed to high school females' decisions about whether to continue taking mathematics courses. The data was collected from 300 10th and 11th grade females in English classes. They were given a Personal Attributes Questionaire of 24 items that are characteristically stereotyped as male or female, and a Mathematics Attitude Scale to determine their feelings about their successes and failures in mathematics. Their mathematics achievement was measured by the Stanford Test of Academic Skills.

The results showed mathematics achievement and masculine self-schema as significant predictors that the students expected to succeed in mathematics. Those whose mathematics achievement was high, along with a high expectation of success and a masculine self-schema, attributed success to ability. Females with lower expectations of success used lack of ability and the difficulty of the task to explain their failure.

"Participation and Performance of Women and Minorities in Mathematics." Report on a project supported by the National Science Foundation and the Montgomery County (Maryland) Public Schools, 1986.

This study explored the factors that contributed to differential participation and performance of males and females in mathematics for 28,000 students in grades K - 12. The data came from report card grades; California Achievement Test results; enrollement in high school mathematics courses; Scholastic Aptitude Test (SAT) results; and questionaires for students, parents, teachers, principals, and counselors.

Enrollment figures showed that after graduation requirements and college admission requirements were complete, there were fewer females enrolled in mathematics courses. Large differences in the math portion of the SAT favoring males were also apparent, even though females had higher grades in the math classes they did take.

The questionaire showed that females were less confident about their mathematical ability, males felt they were better in math than females, and the students claimed that their mothers were not as good in math as their fathers. Males and females had similar aspirations to attend college, but males more often chose careers using math or the physical sciences. Even principals and counselors fostered the belief that mathematics was a male domain.

Pederson, Katherine, Dorothy R. Bleyer, and Patricia B. Elmore. "Attitudes and Career Interests of Junior High School Mathematics Students: Implications for the Classroom." Arithmetic Teacher 32.7 (1985): 45-49.

This study involved 1,937 seventh and eighth graders from 13 junior high schools in rural communities in the midwest. The authors used the Fennema-Sherman Mathematics Attitutes Scales, the Unisex ACT Interest Inventory, and a questionaire about academic plans for mathematics in high school to determine student attitudes and behavior toward mathematics. The Space Relations Test of the Differential Aptitude Test was used to measure spatial visualization.

There were no significant differences between males and females in spatial visualization. Seventh grade females scored significantly higher than males on many of the items in the Fennema-Sherman Attitudes Scales, but their scores decreased from seventh to eighth grade while the scores of their male counterparts increased. Career interests, measured by the Unisex ACT Inventory Test, had significant differences also. Males showed more interest in careers dealing with science and technology, and females had more interest in the creative and applied arts. Any correlation between these career interests and mathematics achievement was not significant.

Plake, Barbara S., Barbara J. Kaplan, and Jay Steinbrunn. "Sex Role Orientation, Level of Cognitive Development and Mathematics Performance in Late Adolesence." Adolescence 21 (1986): 607-13.

This study investigated gender differences in mathematics performance as they relate to sex role identification and level of cognitive development. Cognitive development was measured by the Test of Formal Operations and sex role orientation was gauged by the Bem Sex Role Inventory. Mathematics achievement was measured by ACT College Mathematics Placement Program. The participants were 69 undergraduates at an urban midwestern state university. The researchers found that the combination of cognitive development and psychological sex role orientation was not a significant predictor of mathematics achievement.

Sherman, Julia, and Elizabeth Fennema. "The Study of Mathematics By High School Girls and Boys: Related Variables." American Educational Research Journal 14 (1977): 159-68.

These researchers investigated the relationships between affective and cognitive factors that influence students' decisions to enroll in more mathematics classes. The participants were 10th and 11th grade students who were divided into two groups, one group was definitely planning to take mathematics the following year and the other group contained those who definitely were not or were undecided about enrolling in mathematics. They were administered a mathematics achievement test, the Quick Word Test to measure verbal skills, and the Fennema-Sherman Mathematics Attitudes Scales. Each of these groups were divided again: those who scored above the median of a mathematics achievement test and those who scored below the median.

In the 10th grade, it was found that more males than females in both the lower and upper halves of mathematics achievement intended to enroll in more mathematics courses. The 11th graders showed no difference for those in the upper half, but more males than females in the lower half intended to take more math classes. Gender differences were significant for those in the top half of their classes for achievement on the Quick Word Test, favoring females, and on Math as a Male Domain, favoring males. Overall, differences were more likely to appear between those who intended to take more mathematics and those who did not, than differences between males and females, in attitudes about mathematics.

## Teacher/Student Interactions and Classroom Activities

Gore, Dolores, and Daniel V. Roumagoux. "Wait-Time as a Variable in Sex-Related Differences During Fourth Grade Mathematics Instruction." Journal of Educational Research 76 (1983): 273-75.

This study researched the differences in teacher wait-time for females and males during mathematics instruction. Data was collected by observing 155 fourth graders in rural Arkansas.

Significant differences favoring males were found. Males were allowed more time to respond to teacher questions than females. The authors believed that wait-time differences might affect mathematics achievement and recommended that all students be allowed sufficient time to answer mathematics questions.

Hallinan, Maureen T., and Aage B. Sorensen. "Ability Grouping and Sex Differences in Mathematics Achievement." Sociology of Education 60.4 (1987): 63-72.

The purpose of this study was to determine if ability grouping caused gender differences in mathematics achievement. This longitudinal study of 568 students in the fourth through seventh grades was based on grade-equivalent scores for one of three nationally known achievement tests.

Results showed that sex alone had no significant effect on assignment to the high ability group. When sex of the student was combined with mathematics scores from within the classroom, relative to classmates, high-ranking females were less likely to be assigned to the high ability group than high-ranking males. The same held true for assignment to the low ability group for females.

Sex was shown to have no significant effect on gains in mathematics achievement, nor did ability grouping have any such affect. Teachers may have taken sex into account when assigning ability groups, but these groups did not affect mathematics achievement.

Hart, Laurie E. "Classroom Processes, Sex of Student, and Confidence in Learning Mathematics." Journal for Research in Mathematics Education 20 (1989): 242-60.

This author examined the behavior of teachers with their male and female students in the mathematics classroom. The data came from year two of a three year longitudinal study of classroom processes. An equal number of females and males from seventh grade classes were given the mathematics subtest of the Science Research Associates Assessment Survey to measure math achievement and the Fennema-Sherman Mathematics Attitudes Scales measured student confidence. In addition, two observers recorded information on student-teacher interactions and student time engaged in mathematics.

Significant differences favoring males were seen in public classroom interactions that involved open student volunteers, calling out answers, incorrect student answers, and neutral teacher feedback. Private interactions and interactions that involved teacher-initiated behavioral praise or criticism produced no significant difference among males and females. There was also no significant differences in the time students were engaged in learning mathematics.

Hittner, Amy, and Judith Jacobs. "Mathematics Versus Science: High School Counselors' Perceptions." School Science and Mathematics 86 (1986): 559-66.

In order to determine if males and females were being equally encouraged to enroll in math and science courses in high school, 300 counselors in Virginia were asked to participate in this study. Only the 70 usable student profiles were returned and analyzed. The counselors were given three program planning sheets for fictitious students at three different achievement levels--excellent achievement, good achievement, and average achievement. Half of the profiles used typical male names and the others, typical female names.

The number of math and science courses recommended by the counselors did not differ significantly by sex or for any of the three achievement levels. The authors noted that more math courses were recommended than science courses, particualarly for the students of average achievement. Hittner and Jacobs were encouraged by the implication that the counselors saw mathematics as important for all students.

Peterson, Penelope, and Elizabeth Fennema. "Effective Teaching, Student Engagement in Classroom Activities, and Sex-Related Differences in Learning Mathematics." American Educational Research Journal 22 (1985): 309-35.

These researchers investigated the characteristics of classroom teachers that contributed to gender differences in mathematics achievement. A mathematics achievement test was given to 36 fourth grade classes. The test items were divided into two difficulty levels; low level items were knowledge and skill, and items classified as high level were understanding and application. The achievement test was administered as a pretest in January and a posttest in May. An observer also recorded classroom activities in mathematics.

There were no significant differences in math achievement by gender. Four types of classroom activities, however, did produce significant gender differences. These were competitive activities which negatively affected females' low level achievement, but positively affected males'; cooperative activities which affected females' low and high level achievement positively but negatively affected males'; off-task behavior, which was a predictor of males mathematics achievement; and social behavior which negatively influenced both low and high level achievement for females.

The authors noted that classroom activities had different influences on males and females in learning mathematics and teachers should not to cause inequities for either group with the activities chosen.

## Parent Attitudes and Influences

Holloway, Susan D. "The Relationship of Mothers' Beliefs to Children's Mathematics Achievement: Some Effects of Sex Differences." Merrill-Palmer Quarterly 32 (1986): 231-50.

This study investigated how mothers' beliefs are related to children's achievement in mathematics according to the sex of the child. Mothers from 53 families were interviewed about the attitudes, expectations, and estimates they held regarding their child's performance in mathematics. The children themselves were also questioned concerning their interests in and attitudes about math. They also took the math concepts section of the Iowa Test of Basic Skills. Teachers was asked to rate each child in comparison to other children they taught and about the child's level of motivation, persistence, and concentration.

The teachers' ratings showed no significant differences according to the sex of the child, nor did the children's achievement in mathematics. On the other hand, mothers had higher aspirations in mathematics for males, even when males and females had similar performance records, and were more satisfied with their daughters' past achievement than with the achievement of sons.

Jacobs, Janis E., and Jacquelynne S. Eccles. "Gender Differences in Math Ability: The Impact of Media Reports on Parents." Educational Researcher 14.3 (1985): 20-25.

This study examined the effects of media reports about an article in Science (Benbow and Stanley, 1980) on parents' beliefs concerning the mathematics aptitude of males and females. The media reports implied that there were biological differences among males and females that caused differences in mathematical reasoning ability. Data for the study came from a longitudinal study of 225 parents in southeastern Michigan that was already in progress. The parents were questioned about their beliefs concerning their child's math aptitude, the importance of advanced mathematics courses, their stereotypes regarding sex differences in math ability and the usefulness of math for males and females, and their perceptions of their child's math abilities. About one-fourth of the parents said they had not been exposed to the media coverage on Benbow and Stanley's article.

Those mothers exposed to the media reports and those who had not, differed significantly in their ideas about their daughters' math ability. Those exposed to the coverage believed their daughters had less chance to succeed in mathematics and that their daughters found math more difficult than males. For fathers of daughters, the differences were not significant, but fathers of sons felt that math was more important for males than females after being exposed to the media coverage.

Jayaratne, Toby Epstein. "Impact of Mothers' Math Experiences on Their Daughters' Attitude Toward Math." April, 1987. ED 297 967

This research was part of a larger study concerning attitudes of mothers, fathers, and students. Students in grades five through 12 in a Detroit suburb were given a questionaire to examine their perceptions about mathematics ability.

Significant correlations appeared between mothers' recollections about their experiences in high school mathematics classes (as opposed to their current attitudes) and their daughters' attitudes.

Pederson, Katherine, Dorothy R. Bleyer, and Patricia B. Elmore. "Parent Attitudes and Student Career Interests in Junior High School." Journal for Research in Mathematics Education 17 (1986): 49-59.

The purpose of this study was to determine if parent attitudes and student career interests contribute to sex differences over and above the contributions of spatial visualization, ability, student attitude, student sex, and the career interests and attitudes of parents. Almost 2,000 seventh and eighth graders from 13 rural midwestern junior high schools were tested using a nationally normed standardized achievement test, the Space Relations Test of the Differential Aptitude Tests, the Fennema-Sherman Mathematics Attitudes Scales, and the Unisex ACT Interest Inventory.

The results indicated that parent attitudes contributed to a variation in mathematics achievement between sexes, and student career interests were also a factor. Student sex was shown not to contribute significantly over and above the other factors listed above.

Raymond, Cindy L., and Camilla P. Benbow. "Gender Differences in Mathematics: A Function of Parental Support and Student Sex Typing?" Developmental Psychology 22 (1986): 808-19.

The authors examined the aspects of parental support and encouragement that may cause gender differences in mathematics. The subjects were 300 exceptionally talented junior high school students who had scored either above 700 on the math portion of the SAT or above 630 on the verbal portion. All students and their parents responded to questionaires about home environment concerning mathematics, attitudes, and sex typing.

The first obvious difference was in the number of females in the 700 math/630 verbal group. Only 35 females compared to 173 males were in this group. There were no significant differences in the amount of encouragement or parental involvement for males and females. Males did not receive more encouragement than females in mathematics, though they were significantly more sex stereotyped about mathematically-related areas than their female counterparts.

Yee, Doris K., Janis Jacobs, and Rena Goldsmith. "Sex Equity in the Home: Parents' Influence on their Children's Attitudes About Mathematics." April, 1986. ED 280 717

This research embodied three studies. The first study involved parents of seventh and ninth grade students. The sex of the child had a definite effect on parents' perceptions of the child's math achievement and the importance of taking advanced math in high school. Parents felt math was more difficult for their daughters and it was necessary for females to work harder to succeed in math. The fact that sons and daughters had similar achievement records had no bearing on parent perceptions. Parent beliefs were directly related to children's self-perceptions.

The second study involved 500 parents of fifth through eleventh grades. The results of this study repeated the results of the first study.

Study three was a longitudinal study of 3,300 parents of sixth grade students. In this study, parents' perceptions and expectations for their children in mathematics were strongly related to the children's perceptions of their own ability and the value they placed on mathematics. The children's perceptions were more similar to their parents' perceptions than to those of their teachers.

## Achievement Differences in Elementary and Junior High Schools

Benbow, Camilla P., and Julian C. Stanley. "Sex Differences in Mathematical Ability: Fact or Artifact?" Science 210 (1980): 1262-1264.

The purpose of this study was to determine if differential course-taking was the primary reason for gender differences in mathematics achievement. Seventh and eighth graders participating in the Study of Mathematical Precocious Youth were given the SAT. These students should have had similar mathematics instruction up to this time.

Males and females performed at equal levels on the verbal portion of the SAT, but large sex differences favoring males appeared on the mathematics portion, primarily in the upper levels of mathematical reasoning. Males outnumbered females in a ratio of two to one on SAT math scores over 500.

The authors concluded that sex differences in mathematics achievement could not be attributed to differential course-taking, but must have resulted from "superior male mathematical ability."

Benbow, Camilla P., and Julian C. Stanley. "Sex Differences in Mathematical Reasoning: More Facts." Science 222 (1983): 1029-1031.

This research was a continuation of that described in Benbow and Stanley's 1980 article, using a new group of students in a regional talent search conducted by John Hopkins University and from a nationwide talent search. The study involved approximately 65,000 seventh graders throughout the country.

Even though males and females showed similar participation in the talent searches, males outscored females in a ratio of 13:1 for those scoring over 700 on the mathematics portion of the SAT. This led the authors to conclude that sex differences in mathematics achievement might have been caused by social conditioning or expectations, though these factors were not examined by this study.

Brandon, Paul R., Barbara J. Newton, and Ormond W. Hammond. "Children's Mathematics Achievement in Hawaii: Sex Differences Favoring Girls." American Educational Research Journal 24 (1987): 437-61.

This study used data from the Hawaii State Department of Education on the statewide administration of the Stanford Achievement Test in grades four, six, eight and 10. The research compared results for the four major ethnic groups represented in Hawaii (Caucasians, Filipinos, Hawaiians, and Japanese).

Overall, females exhibited higher achievement than males in mathematics. When the results were examined by ethnic group, only Caucasian males showed significantly higher mathematics achievement than females, but these differences were smaller that the significant differences favoring females among the other ethnic groups.

Ethington, Corinna A. "Gender Differences in Mathematics: An International Perspective." 1988. ED 299 194

This research examined patterns of gender differences in mathematics on specific problem types in eight countries. The data was collected as part of the Second International Mathematics Study of 40,000 students in grades seven and eight. Students were tested at the beginning and at the end of the 1982-83 school year.

The author hypothesized that males would show more achievement on problems involving measurement and probability, and problems with a spatial component; and females would score higher on problems using computational skills, abstract deductive reasoning, and the construction and analysis of symbolic relationships. The results showed that gender differences were very small (favoring females more often than males) and no significance could be attributed to sex in any of the content areas.

Fennema, Elizabeth, and Lindsay A. Tartre. "The Use of Spatial Visualization in Mathematics by Girls and Boys." Journal for Research in Mathematics Education 16 (1985): 184-206.

This study discussed the relationship of spatial visualization and verbal skills in problem solving. The participants for this study were chosen because of the descrepancy between their spatial skills and their verbal skills. More than 650 sixth graders from Madison, Wisconsin were given tests to measure spatial visualization, verbal skills, and mathematics achievement. The students participated in three phases of an individual interview. They were asked to verbalize a written problem, draw a picture to help solve the problem and use the picture to solve the problem, then describe how the picture was used while solving the problem.

Males were able to solve significantly more problems than females, especially males who had fewer spatial visualization skills (these males had the highest achievement scores). Males did better on fraction problems and supplied more pictoral information, but females were able to verbalize more information. Females also used the picture more often. Unfortunately, these things did not help females solve more problems correctly. Overall, any sex differences in mathematics achievement were small.

Hanna, Gila. "Sex Differences in the Mathematics Achievement of Eighth Graders in Ontario." Journal for Research in Mathematics Education 17 (1986): 231-37.

This researcher investigated the scope of sex-related differences in mathematics achievement. Hanna studied 3,523 students from 130 schools in Ontario, Canada who were part of the Second International Mathematics Study. All students took a pretest and a posttest covering arithmetic, algebra, geometry, probability and statistics, and measurement.

There were no significant differences between the sexes on problems involving arithmetic, algebra, and probability and statistics. Males responded with significantly more correct answers on problems in geometry and measurement. The author also examined the incorrect responses given, but no significant differences were shown for any of the incorrect responses. However, females failed to respond to significantly more questions than males. Though females did respond to more questions on the posttest than they did on the pretest, males answered more questions also, so this gap remained. There was no significant differences between males and females in the amount of improvement from the pretest to the posttest. The author concluded that the differences indicated in the study must be caused by factors other than socioeconomic level, formal training, and quality of teaching since males and females were equivalent in these areas.

Marshall, Sandra P., and Julie D. Smith. "Sex Differences in Learning Mathematics: A Longitudinal Study With Item and Error Analyses." Journal of Educational Psychology 79 (1987): 372-83.

This longitudinal study examined the performance of students in elementary school mathematics from third to sixth grade. The study used data from the California Assessment Program's Surveys of Basic Skills for approximately 6,00 students in six problem categories.

Third grade females had significantly higher scores for the categories of computation and nontraditional problems, and they maintained this difference only in computation by the sixth grade. Overall, females in the third grade performed better than third grade males, but this advantage had almost disappeared by sixth grade.

The authors also examined level of difficulty among the categories. It was noted that males and females had similar feelings about the difficulty of the categories at the third grade level, but by the sixth grade, males were likely to feel that all categories had a similar level of difficulty while females felt some categories easier and others more difficult.

In the examination of individual items, females had a higher proficiency on a greater number of items than males (41% compared to 15%) in the third grade but by sixth grade, they were fairly equal on the number of items on which each group perfomed better than the other.

Weiner, Nell C., and Sharon E. Robinson. "Cognitive Abilities, Personality and Gender Differences in Math Achievement of Gifted Adolescents." Gifted Child Quarterly 30 (1986): 83-87.

This research involved 139 seventh and eighth graders attending the Project for the Study of Academic Precocity who scored above 400 on the SAT mathematics portion. The students also took the Group Embedded Figures Test, the Differential Aptitude Test and the California Personality Inventory.

Results showed that spatial visualization did not contribute to any differences between males and females and was deleted from the study. There were no significant differences in verbal abiltiy. Mathematical reasoning ability was the major discriminator favoring males. The authors noted that not only were there significant differences between males and females in mathematical reasoning ability, but that more males were able to show this ability.

## Achievement Differences in High School

Awartani, Marwan, and Mary W. Gray. "Cultural Influences on Sex Differentials in Mathematics Aptitude and Achievement." International Journal of Mathematical Education in Science and Technology 20 (1989): 317-20.

This study examined sex differences in mathematics achievement for classes of 14-year-olds and freshmen students in the Faculty of Science at Bir Zeit University in the Palestinian West Bank. Both groups were administered an Arabic test similar in content to the mathematics portion of the SAT.

Results showed that the gender differences in mathematics achievement were significant for the 14-year-olds, but not for the freshmen students. The authors concluded, in the case of the 14-year-olds, the more nearly the population resembles those used in United States studies, the more apparent the sex differences in math achievement. For the freshmen students, they offered an explanation for the lack of differences. That freshmen females were even attending college in the first place was an indication that they were not willing to conform to the usual stereotype of math as a male domain and were more likely to be serious students.

Doolittle, Allen E., and T. Anne Cleary. "Gender-Based Differential Item Performance in Mathematics Achievement Items." Journal of Educational Measurement 24 (1987): 157-66.

This study was designed to determine the presence of gender-based differential item performance in items measuring mathematics achievement. More than 1,300 students were given the Mathematics Usage portion of the ACT Assessment Testing program which tests mathematical reasoning ability.

Differences between males and females in mathematics achievement were shown in a number of categories. The Geometry, and Arithmetic and Algebraic Reasoning sections were relatively easier for males, while females had an easier time with the sections involving Intermediate Algebra, and Arithmetic and Algebraic Operations. The authors concluded that some gender-based differences did exist, but it was important to look at the types of problems that produced those differences. Since males showed Geometry was easier for them, this may have supported the theory that males had better spatial skills at this level. It also appeared that males had better reasoning skills, while females had better algorithmic or computational skills.

Fennema, Elizabeth, and Julia Sherman. "Sex-Related Differences in Mathematics Achievement, Spatial Visualization and Affective Factors." American Educational Research Journal 14 (1977): 51-71.

The purpose of this study was to determine how the previous study of mathematics was related to sex differences in mathematics achievement. Fennema and Sherman studied all 10th and 11th grade students enrolled in "on-grade" mathematics courses for all public high schools in a Wisconsin city. The students were tested on mathematics achievement, verbal ability, spatial visualization, and the affective factors measured by the Fennema-Sherman Attitudes Scales. Information about the number of mathematics courses taken was also collected.

Results showed that for students with similar mathematics backgrounds, there were few differences between males and females in mathematics achievement. Spatial visualization was only a small factor in the differences between males' and females' achievement. Males exhibited more mathematics confidence than females, and males, more often than females, stereotyped math as a male domain. Females did not continue to take mathematics as often as males. The authors noted that it was not surprising that females did not perform as well as males on mathematics tests, if they had not taken as many advanced courses.

Jones, Lyle V. " The Influence on Mathematics Test Scores by Ethnicity and Sex, of Prior Achievement and High School Mathematics Courses." Journal for Research in Mathematics Education 18 (1987): 180-86.

This study used data from approximately 7,500 students involved in the project High School and Beyond. The purpose was to determine how mathematics courses taken affect student achievement.

Results showed, on a mathematics achievement test, males scored higher than females (60% compared to 56% correct), though these percentages increased for both groups as the level of advanced mathematics credits increased. The data also revealed that a greater percentage of males than females had four or more math credits in high school.

Moore, Elsie G.J., and A. Wade Smith. "Sex and Ethnic Group Differences in Mathematics Achievement: Results from the National Longitudinal Study." Journal for Research in Mathematics Education 17 (1986): 25-36.

This article reviewed the National Longitudinal Study (1980). It was different from most other studies in that the data was collected from a national sample of almost 12,000 males and females ages 15 to 22 in direct home visits, rather than only those young people who happened to be enrolled in school at the time. The researchers used the Armed Services Vocational Aptitude Battery (ASVAB) and examined the results from the Arithmetic Reasoning and Mathematical Knowledge subtests.

In the Arithmetic Reasoning Test, no sex differences were observed in those persons who had completed grades K - 8, but there was a significant difference favoring males among those who had completed grade nine or more. It was noted that these differences between the sexes increased with increased educational level.

For the Mathematical Knowledge Test, females completing grades K - 8 had slightly higher scores than their male counterparts. No sex differences were observed for those finishing grades nine to 11, but the males who had finished high school or completed at least some college had a significant advantage over the females in the same group.

The authors concluded that these results matched many earlier studies regarding sex differences in mathematics achievement since it appeared that sex differences could be attributed to differential course-taking in high school.

Pattison, Philippa, and Norma Grieve. "Do Spatial Skills Contribute to Sex Differences in Different Types of Mathematical Problems?" Journal of Educational Psychology 76 (1984): 678-89.

The purpose of this study was to determine if spatial skills were factors in sex differences in mathematics achievement. The study was done in two single-sex schools with students in grades 10 and 12 in Melbourne, Australia. The students were administered a mathematics test containing exploratory problems assosciated with the development of abstract algebra and discrete mathematics, and four spatial tests.

The results of this study showed there were sex differences favoring males on the mathematical test and on some of the spatial tests, but the types of spatial skills having the strongest link to mathematical problems showed no significant differences. The authors concluded that sex differences in mathematics could not be attributed to only differences in spatial skills.

Rallis, Sharon F., and Sharon A. Ahern. "Math and Science Education in High Schools: A Question of Sex Equity?" April, 1986. ED 270 326

This study involved the graduating class of 1985 in Rhode Island. The authors compared the enrollment and grades in math and science courses for these students, the sex of the student, and their SAT scores.

The results showed that males and females graduating from high school in Rhode Island were taking equal amounts of math and science courses, especially upper level courses and females often earned higher grades in those classes. Student scores on the SAT did not correspond to those findings. Females scored approximately 50 points lower than males on the mathematics portion. The authors attributed this to a number of different reasons, including the possibility that more females than males took the SAT or that females did not achieve as well as males in competitive activities.

Senk, Sharon, and Zalman Usiskin. "Geometry Proof Writing: A New View of Sex Differences in Mathematics Ability." American Journal of Education 91 (1983): 187-201.

Senk and Usiskin studied 1,364 students who were enrolled in high school geometry from 11 high schools in five states. There were almost equal numbers of males and females participating in the study. The purpose was to determine if sex differences existed in a high-level cognitive task like geometry proof-writing. The students were given a test to determine their knowledge of geometry terminology and facts during the first week of school. They also took a standardized geometry achievement test during the last week of school, along with one of three different forms of a proof test (three forms were devised so a larger number of proofs could be analyzed). On the proof-writing test the students were asked to complete six items: fill in four missing statements or reasons in a proof; translation of a verbal statement into an appropriate figure, "given," "prove"; and four complete proofs.

Females scored significantly lower than males on the beginning level of knowledge test. When examining the mean scores on the proof test, the results showed no significant differences in the scores of males and females. In an item by item analysis of the 18 possible items (six on each form), males scored significantly higher on a full proof and females on a translation; the authors noted that at the .05 significance level two differences in 18 can be attributed to chance. So although females began the year with less knowledge of geometry, by the end of the year there was no significant difference in their knowledge of geometry proof-writing.

In addition, to test the conclusions of Benbow and Stanley's (1980) study, the authors examined three subsets of high-achieving students that closely matched the population in the Benbow and Stanley study. Senk and Usiskin found no significant differences between high-achieving females and males in their ability to write proofs. The authors concluded that "when test items cover material that is taught and learned almost exclusively in the classroom, no pattern of sex differences tends to be found."

Smith, Stuart E., and William J. Walker. "Sex Differences on New York State Regents Examinations: Support for the Differential Course-Taking Hypothesis." Journal for Research in Mathematics Education 19 (1988): 81-85.

These researchers investigated the hypothesis that females score as well as males on the New York State Regents exam in mathematics. The study was based on the exams for the ninth, 10th, and 11th years of mathematics and the authors assumed the males and females taking these tests had equivalent mathematics backgrounds since those who took 10th year mathematics had completed ninth year successfully, and so on. The data also showed that a similar number of males and females took each of the three exams.

For the ninth and 11th years, females scored higher than males, though the differences were not significant. Males scored significantly higher than females on the 10th year exam, but these differences were small (the difference was equivalent to one-half of a question). The authors concluded that if females had the same level of instruction in mathematics as males, they would produce the same level of achievement on curriculum-specific tests.

Strauss, Sheila M. "Girls in the Mathematics Classroom: What's Happening With Our Best and Brightest?" Mathematics Teacher 81 (1988): 533-37.

This study investigated how the gender makeup of the classroom affected mathematics achievement. It was conducted at Hunter College High School which admitted males for the first time in 1980. This study compared the last five years as a single-sex school with the first five years as a codeducational school in five areas: Advanced Placement (AP) BC Calculus scores; mathematics aptitude on the SAT; Mathematics Achievement Tests, levels I and/or II; overall grade point average (GPA); and GPA of mathematics courses.

Significant sex differences favoring males appeared in all of the categories, except for the overall GPA. In this case, the females showed a higher overall GPA, though females in the mixed gender group had a lower overall GPA than those in the single-sex group.

The author suggested some areas for further consideration and a follow-up study at Hunter is being planned to examine whether mathematically-able males and females are treated differently.

## Summary

Student attitudes involved a number of factors that affected mathematics achievement. One major concern about gender differences in mathematics achievement has been the fact that fewer females than males have entered math-related careers. According to the studies by Besag and Wahl, Pederson and others (1985), and the study done in the Montgomery County Public Schools, females still were more interested in marriage and family or careers in the creative and applied arts than mathematics. Burton also found that females were not likely to expect to use math in the future, though males did expect to (Burton and others). Even though Pederson and others (1985) found no correlation between achievement and career interests, and males and females took the same amount and level of math courses (Besag and Wahl), females have still been underrepresented in math-related careers.

One reason for this underrepresentation may be that females were often found to have less confidence than males in their ability to succeed in mathematics (Burton and others, and Montgomery County Public Schools). Krauser and Ballif found that females explain their lack of success on less ability than males and males may have contributed to this attitude with their own stereotyped idea that males are indeed better than females in mathematics ability. Pederson and others (1985) found in their study that any positive attitudes that females did have, had decreased from seventh to eighth grade. Generally, positive attitudes about math translated into greater mathematical

achievement for males than females (Ethington and Wolfle). On a positive note, Plake and others found that sex role orientation had no effect on mathematics achievement, so not all females held negative attitudes towards mathematics. The attitudes of males and females who planned to continue to study mathematics differed more from those who did not plan to continue than they did from each other (Sherman and Fennema).

The interactions between students and teachers and the types of learning activities planned by teachers may have contributed to gender differences in mathematics achievement. Gore and Roumagoux found that males were given more wait-time in mathematics when responding to teacher questions. Males were also interacting with teachers more often through calling out answers and volunteering in class (Hart).

The study done by Hallinan and Sorensen showed females less likely to be in a high ability group in classes which used ability grouping in learning mathematics. On the other hand, gender protected them from being assigned to the low ability group. But, to whichever group males or females were assigned, made no difference in their mathematics achievement as ability groups were shown to have no significant effect on achievement.

Teachers need to be concerned with the type of learning activities that students are engaged in. What contributed to one gender's achievement was a hinderance to the other sex. Peterson and Fennema found that though cooperative activities contributed to females' math achievement, they had a negative effect on the

achievement of males. The reverse proved to be true for competitive activities.

Hittner and Jacobs were encouraged by their study involving a group of Virginia counselors. The counselors saw the importance of math for all high school students and recommended the same number of mathematics courses for students, regardless of gender.

Though several studies have shown that teachers' attitudes and activities affect student achievement in mathematics, Yee and others, and Pederson and others (1986) found that children's perceptions of their own abilities are more closely related to their parents' perceptions than those of teachers. Mothers were found by Holloway to have higher aspirations of mathematical achievement for males than for females, even when males and females had the similar levels of mathematical performance. Daughters were affected by mothers' recollections of their own high school experiences in mathematics (Jayaratne).

Parents often felt that math was more difficult for females than for males (Yee and others). After being exposed to media reports that males naturally have more mathematical ability than females, mothers came to believe that females had less ability. Fathers of daughters were not influenced by such media coverage, but fathers of sons were more likely to think that math was more important for males than for females (Jacobs and Eccles).

Raymond and Benbow found no evidence that males received more help and encouragement to study mathematics from parents. They did find, however, that males themselves were more sex

stereotyped in regarding math as a male domain, as did Fennema and Sherman.

Students have been tested by a variety of mediums to determine if gender differences in mathematics existed and if so, why. Bendbow and Stanley (1980, 1983) examined the results of mathematically able seventh and eighth graders who took the SAT. Even though males and females had comparable scores on the verbal portion, males did significantly better on the mathematics portion. In fact, males outscored females in a ratio of 13:1 for math scores over 700. Weiner and Robinson also found males had significantly more reasoning ability. In the study done by Hanna, males performed better on geometry and measurement problems. Though there were no significant differences for problems involving arithmetic, algebra, and probability and statistics, females overall responded to fewer questions than males.

Though spatial visualization is one area that has been attributed to sex differences in mathematics achievement, the studies by Fennema and Tartre, and Weiner and Robinson showed that spatial visualization did not contribute to any observed sex differences in achievement. Gender differences in mathematics achievement could not be attributed to differences in the spatial skills observed by Pattison and Grieve. In this case, they observed males were better at some spatial skills, but not on the spatial skills usually required to solve mathematics problems.

Not all cases have shown significant sex differences favoring males. Ethington found small differences favoring

females, but concluded that differences in achievement were not attributable to sex. Brandon and others found females outperformed males in their study of Hawaiian ethnic groups (though when examined individually, Caucasian males were found to to achieve higher levels than females). Marshall and Smith also found females in the third grade with greater mathematical achievement than males, but by sixth grade females had lost ground. In the longitudinal study by Moore and Smith, there were no sex differences in achievement for those who had completed grades K - 8 in Arithmetic Reasoning, and in fact, females in that group scored significantly better on Mathematical Knowledge. Females did not maintain their lead in Mathematical Knowledge, however, since no differences between the sexes were observed in achievement for those completing grades nine through 11, and males surpassed females in achievement for those who had completed high school or had attended some college. In an examination of freshmen at Bir Zeit University in the Palestinian West Bank, no significant differences existed in mathematics achievement, though this might have been attributed to the fact that females have been discouraged from attending college and therefore were more serious about their studies than the males (Awartani and Gray).

Doolittle and Cleary noted that sex differences in mathematics achievement might be attributed to the types of problems students are expected to solve. They observed sex differences in achievement, some that favored females and some that foavored males. Males were significantly better at

geometry, and arithmetic and algebra reasoning. Females were better at intermediate algebra, and arithmetic and algebra operations.

One of the major theories about sex differences in mathematics achievement has been the fact that males have often taken more mathematics classes than females, particularly at the upper levels. This was the case in the study by Jones. But a number of other studies showed that females and males took comparable numbers and levels of mathematics courses (Rallis and Ahern, Strauss, Smith and Walker). Females had higher grades than their male counterparts in the study by Rallis and Ahern, but like the situation at Hunter College High School (Strauss), they still scored considerably lower than males on the SAT.

In three studies, (Fennema and Sherman, Smith and Walker and Senk and Usiskin) it was found that if females and males had the same level of instruction, they performed equally well on curriculum-specific tests.

## Conclusions

There have been varying conclusions about the existence of sex differences in mathematics achievement, as this review of the research has shown. Some of the more recent studies have found at least a decline in gender differences, and in some cases, no differences at all in the mathematics achievement of females and males. It is unlikely that males and females inherently differ in mathematical ability. Rather, when differences do exist, they were probably caused by a number of affective factors. Student attitudes may affect females' decisons about continuing in mathematics beyond the minimum requirements in high school. Females often have fewer role models of women successful in mathematics (Hallinan and Sorensen, 1987: 63); and although males are more apt than females to classify math as a male domain, this may have an indirect effect on females striving to be accepted by their male peers (Raymond and Benbow, 1986: 808).

Parents, too, affect the way females perceive mathematics. One reason females have given for not continuing in math has been its future usefulness. But where do females get their perceptions of a subject's usefulness?

Teachers must provide learning activities that cater to the learning styles of all students. Teachers may also hold the stereotype of math as a male domain, and therefore have higher expectations for males. This may then lead to more wait-time for males, which may have an effect on males' and females' mathematical achievement, a vicious circle!

Most importantly, caution should be used whenever mathematics achievement is measured by the SAT or similar tests in which experiences outside of the classroom may have an affect of the outcome. Mathematical ability should be determined by the extent to which students learn what is taught in the classroom (Senk and Usiskin, 1983: 198-99).

## Recommendations

1. Teachers should provide information about math-related careers and the amount of mathematics required to enter those careers.

2. Teachers should encourage all students to take as much mathematics as possible and offer a broad mathematics curriculum which will make this possible. Middle grade teachers, especially, must be aware of the important influence they can have.

3. Teachers should allow both males and females the same amount and the same quality of time to ask and answer questions in class.

4. Teachers should provide students with equal amounts of cooperative and competitive learning activities, so each can learn in the style best suited to his/her needs.

5. Teachers should provide activities which allow students to practice spatial skills.

6. Teachers should be aware of their students' current attitudes about mathematics. Students could keep journals about their experiences in mathematics.

7. Educators should minimize the use of standardized tests to determine achievement and examine any that are used for sex biases.

8. Parents should be made aware of the importance of mathematics for all students, not just males; and of how their own attitudes affect the attitudes of their children.

9. School districts may be able to participate in (or develop one of their own) an intervention program designed to encourage females to participate in the study of mathematics. Some of these programs are (Becker, 1987: 225-30):
   - Math for Girls, Lawrence Hall of Science, UC-Berkeley
     special after school class for females ages 6-14.
   - SPACES, Lawrence Hall of Science, UC-Berkeley
     develops career-awareness and important mathematical problem-solving skills for females.
   - Expanding Your Horizons, Math/Science Network, San Francisco
     one-day career conferences for junior and senior high school females; has spread throughout the country.
   - Visiting Women Scientists, National Science Foundation
     female mathematicians and scientists visit high schools.
   - AAA Math
     sessions invovlving counseling, career information, and small group tutoring.

- TEAM
  eight modules for use in methods courses for preservice elementary teachers dealing with mathematics and attitudes.
- Multiplying Options and Subtracting Bias
  videotapes for workshops for parents, teachers, counselors and peers on improving females' attitudes about math.
- Women and Mathematics Education, an affiliate of the National Council of Teachers of Mathematics
  network for those interested in increasing the participation of females in mathematics.

10. Research must continue to investigate further what can be done to close the gap in mathematics achievement.

11. The SAT should be examined to determine if it is a fair predictor of achievement for both males and females.

# Bibliography

Awartani, Marwan, and Mary W. Gray. "Cultural Influences on Sex Differentials in Mathematics Aptitude and Achievement." International Journal of Mathematical Education in Science and Technology 20 (1989): 317-20. (22, 32)

Becker, Joanne Rossi. "Sex Equity Intervention Programs Which Work." School Science and Mathematics 87 (1987): 223-32. (36)

Benbow, Camilla P., and Julian C. Stanley. "Sex Differences in Mathematical Ability: Fact or Artifact?" Science 210 (1980): 1262-1264. (3, 15, 18, 26, 31)

Benbow, Camilla P., and Julian C. Stanley. "Sex Differences in Mathematical Reasoning: More Facts." Science 222 (1983): 1029-1031. (3, 18, 31)

Besag, Frank, and Maureen Wahl. "Gender, Race, Ethnicity and Math Avoidance." Paper presented at the Anual Meeting of the American Educational Research Association, 1987. (7, 28)

Brandon, Paul R., Barbara J. Newton, and Ormond W. Hammond. "Children's Mathematics Achievement in Hawaii: Sex Differences Favoring Girls." American Educational Research Journal 24 (1987): 437-61. (19, 32)

Burton, Grace M. "Revealing Images." School Science and Mathematics 84 (1984): 199-207. (1, 7, 28)

Burton, Grace M., Ken Peterson, and Dale Baker. "Sex Differences in Geometry Students' Perceptions of Ideal and Actual Behavior." Journal for Research in Mathematics Education 18 (1985): 55-60. (8, 28)

Doolittle, Allen E., and T. Anne Cleary. "Gender-Based Differential Item Performance in Mathematics Achievement Items." Journal of Educational Measurement 24 (1987): 157-66. (5, 22, 32)

Ethington, Corinna A. "Gender Differences in Mathematics: An International Perspective." 1988. ED 299 194 (19, 31)

Ethington, Corinna A., and Lee M. Wolfle. "A Structural Model of Mathematics Achievement for Men and Women." American Educational Research Journal 23 (1986): 65-75. (8, 29)

Fennema, Elizabeth, and Julia Sherman. "Sex-Related Differences in Mathematics Achievement, Spatial Visualization and Affective Factors." American Educational Research Journal 14 (1977): 51-71. (3, 23, 31, 33)

Fennema, Elizabeth, and Lindsay A. Tartre. "The Use of Spatial Visualization in Mathematics by Girls and Boys." Journal for Research in Mathematics Education 16 (1985): 184-206. (6, 20, 31)

Good, Carter V., ed. Dictionary of Education 3rd ed. New York: McGraw-Hill, 1973. (4, 5, 6)

Gore, Dolores, and Daniel V. Roumagoux. "Wait-Time as a Variable in Sex-Related Differences During Fourth Grade Mathematics Instruction." Journal of Educational Research 76 (1983): 273-75. (6, 12, 29)

Hallinan, Maureen T., and Aage B. Sorensen. "Ability Grouping and Sex Differences in Mathematics Achievement." Sociology of Education 60.4 (1987): 63-72. (12, 29, 34)

Hanna, Gila. "Sex Differences in the Mathematics Achievement of Eighth Graders in Ontario." Journal for Research in Mathematics Education 17 (1986): 231-37. (20, 31)

Hawes, Gene R., and Lynne Salop Hawes, ed. The Concise Dictionary of Education New York: Reinhold, 1982. (4, 5, 6)

Hart, Laurie E. "Classroom Processes, Sex of Student, and Confidence in Learning Mathematics." Journal for Research in Mathematics Education 20 (1989): 242-60. (5, 13, 29)

Hearne, Jill T. "Mathematics and Science Equity: Do You Have It? How Do You Get It?" January, 1986. ED 278 758 (5)

Hittner, Amy, and Judith Jacobs. "Mathematics Versus Science: High School Counselors' Perceptions." School Science and Mathematics 86 (1986): 559-66. (13, 30)

Holloway, Susan D. "The Relationship of Mothers' Beliefs to Children's Mathematics Achievement: Some Effects of Sex Differences." Merrill-Palmer Quarterly 32 (1986): 231-50. (15, 30)

Jacobs, Janis E., and Jacquelynne S. Eccles. "Gender Differences in Math Ability: The Impact of Media Reports on Parents." Educational Researcher 14.3 (1985): 20-25. (15, 30)

Jayaratne, Toby Epstein. "Impact of Mothers' Math Experiences on Their Daughters' Attitude Toward Math." April, 1987. ED 297 967 (16, 30)

Jones, Lyle V. " The Influence on Mathematics Test Scores by Ethnicity and Sex, of Prior Achievement and High School Mathematics Courses." Journal for Research in Mathematics Education 18 (1987): 180-86. (23, 33)

Krauser, Barbara Z., and Bonnie L. Ballif. "Casual Attributions of Adolescent Females in a Masculine Domain." 1988. ED 291 573 (6, 9, 28)

Marshall, Sandra P., and Julie D. Smith. "Sex Differences in Learning Mathematics: A Longitudinal Study With Item and Error Analyses." Journal of Educational Psychology 79 (1987): 372-83. (1, 21, 32)

Moore, Elsie G.J., and A. Wade Smith. "Sex and Ethnic Group Differences in Mathematics Achievement: Results from the National Longitudinal Study." Journal for Research in Mathematics Education 17 (1986): 25-36. (24, 32)

--------. "Participation and Performance of Women and Minorities in Mathematics." Report on a project supported by the National Science Foundation and the Montgomery County (Maryland) Public Schools, 1986. (9, 28)

Pattison, Philippa, and Norma Grieve. "Do Spatial Skills Contribute to Sex Differences in Different Types of Mathematical Problems?" Journal of Educational Psychology 76 (1984): 678-89. (24, 31)

Pederson, Katherine, Dorothy R. Bleyer, and Patricia B. Elmore. "Attitudes and Career Interests of Junior High School Mathematics Students: Implications for the Classroom." Arithmetic Teacher 32.7 (1985): 45-49. (10, 28)

Pederson, Katherine, Dorothy R. Bleyer, and Patricia B. Elmore. "Parent Attitudes and Student Career Interests in Junior High School." Journal for Research in Mathematics Education 17 (1986): 49-59. (5, 16, 30)

Peterson, Penelope, and Elizabeth Fennema. "Effective Teaching, Student Engagement in Classroom Activities, and Sex-Related Differences in Learning Mathematics." American Educational Research Journal 22 (1985): 309-35. (4, 14, 29)

Plake, Barbara S., Barbara J. Kaplan, and Jay Steinbrunn. "Sex Role Orientation, Level of Cognitive Development and Mathematics Performance in Late Adolesence." Adolescence 21 (1986): 607-13. (10, 29)

Rallis, Sharon F., and Sharon A Ahern. "Math and Science Education in High Schools: A Question of Sex Equity?" April, 1986. ED 270 326 (1, 25, 33)

Raymond, Cindy L., and Camilla P. Benbow. "Gender Differences in Mathematics: A Function of Parental Support and Student Sex Typing?" Developmental Psychology 22 (1986): 808-19. (16, 30, 34)

Senk, Sharon, and Zalman Usiskin. "Geometry Proof Writing: A New View of Sex Differences in Mathematics Ability." American Journal of Education 91 (1983): 187-201. (3, 26, 33, 35)

Sherman, Julia, and Elizabeth Fennema. "The Study of Mathematics By High School Girls and Boys: Related Variables." American Educational Research Journal 14 (1977):159-68. (3, 5, 11, 29)

Smith, Stuart E., and William J. Walker. "Sex Differences on New York State Regents Examinations: Support for the Differential Course-Taking Hypothesis." Journal for Research in Mathematics Education 19 (1988): 81-85. (27, 33)

Strauss, Sheila M. "Girls in the Mathematics Classroom: What's Happening With Our Best and Brightest?" Mathematics Teacher 81 (1988): 533-37. (1, 27, 33)

Weiner, Neil C., and Sharon E. Robinson. "Cognitive Abilities, Personality and Gender Differences in Math Achievement of Gifted Adolescents." Gifted Child Quarterly 30 (1986): 83-87. (21, 31)

Yee, Doris K., Janis Jacobs, and Rena Goldsmith. "Sex Equity in the Home: Parents' Influence on their Children's Attitudes About Mathematics." April, 1986. ED 280 717 (17, 30)

Student Qualifications

| | |
|---|---|
| NAME: | Deborah Schaalma |
| ADDRESS: | 633 S. 33rd Street<br>South Bend, Indiana 46615 |
| EDUCATIONAL BACKGROUND: | B.A. mathematics, Western Michigan University |
| EMPLOYMENT EXPERIENCE: | South Bend Community School Corporation<br>Clay High School (9 years)<br>Jackson Middle School (1 semester) |
| QUALIFICATIONS TO UNDERTAKE THIS STUDY: | 35 graduate hours at Indiana University at South Bend |
| INTEREST IN TOPIC: | As a mathematics teacher, I am concerned about girls who are not using their full potential in mathematics because they see it as unfeminine or have been told it is not important for them. I hope to become more effective in encouraging girls to pursue more advanced mathematics courses and careers in mathematics-related fields by understanding why they avoid them. |